Differential Lung Toxicity of Biomass Smoke from Smoldering and Flaming Phases Following Acute Inhalation Exposure

Yong Ho Kim[1], Charly King[1], Q. Todd Krantz[1], Ingrid J. George[2], Marie McGee[1], Lisa Copeland[1], Michael D. Hays[2], Matthew S. Landis[3], Mark Higuchi[1], Stephen H. Gavett[1], M. Ian Gilmour[1]

[1]NHEERL, [2]NRMRL and [3]NERL, US EPA, Research Triangle Park, NC, USA

We previously demonstrated that, on a mass basis, lung toxicity associated with particulate matter (PM) from flaming smoke aspirated into mouse lungs is greater than smoldering PM. This finding however has to be validated in inhalation studies to better predict real-world exposures. Thus, we modified an existing combustion system to precisely control and maintain smoke concentrations during the combustion process. We generated biomass smoke from peat and eucalyptus fuels under smoldering and flaming phases for up to 1 hour, and measured PM and volatile organic compounds (VOCs) levels. Smoldering PM levels were ~10 times higher than flaming PM with carbon monoxide (CO) held at similar levels to equalize potentially interfering CO health effects. Mice were exposed by inhalation for 1 hour/day for 2 days and then assessed for lung toxicity at 4 and 24 h after the second exposure. PM levels were ~40 and ~4 mg/m^3 under smoldering and flaming phases, respectively, while CO levels ranged from ~80 to 110 ppm for all exposures. Notably, VOCs/PM ratios were higher (up to 7 times) in flaming than smoldering smoke. Smoldering peat and eucalyptus smoke elicited significant inflammation (neutrophils) in mouse lungs at 4 h post-exposure while flaming smoke from either fuel caused even greater lung inflammation at 24 h post-exposure. Similarly, a significant increase in an index of airflow obstruction was observed in mice exposed to flaming peat and eucalyptus, and smoldering eucalyptus smoke immediately after each day of exposure. These results suggest that although flaming smoke contains much less PM mass than smoldering smoke, the health risk of this exposure is, on a mass basis, greater than that from smoldering emissions. These observations support the concept that health risks of smoke exposure vary depending on the type of fuel and combustion conditions. [This abstract does not represent EPA policy]